DELAYED AND CURRENT STIMULUS CONTROL IN SUCCESSIVE DISCRIMINATIONS

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In a successive discrimination in which successively alternating red and green hues signaled component variable-interval schedules, sensitivity of the ratio of responses in the two components to variation in the component reinforcer ratio decreased systematically during the course of the component. This decrease in stimulus control or discrimination over the course of the component was shown to be the result of delayed control of responding during the component by the stimulus transition between components. When the red–green stimulus transition was altered by interpolating a white stimulus at the end of each 60-s component, discrimination at the beginning of the component (measured by the power-function exponent for sensitivity to reinforcement) was reduced. Conditions with the white stimulus inserted in other quarters of the component indicated that the current discriminative stimulus exerts control over responding throughout the component, whereas during about the first half of the component, response differentials are influenced by the transition between discriminative stimuli.

Key words: Successive discrimination, delayed stimulus control, sensitivity to reinforcement, multiple schedules, variable-interval schedules, key peck, pigeon

In successive discriminations, different stimuli are presented in succession, each signaling a particular component reinforcement schedule. Behavior in successive discriminations is constrained temporally in that reinforcers for behavior in a temporally distant stimulus are not accessible in the current stimulus (McLean & White, 1983; White, 1978). It is therefore plausible that behavior is controlled by the current stimulus, as established by early and contemporary treatments of discriminative stimulus control. The question raised by the present research is whether behavior is also under delayed control by the stimulus in a preceding component or by the between-component stimulus transition. Such a possibility is pertinent to relational theories of discrimination that require conjoint control by temporally separated stimuli or their relation. For example, Lawrence (1963) suggested that stimulus comparison could serve as the main mechanism of discrimination. Thus, discrimination is maximal when the stimuli are temporally proximal.

A possible instance of the combined effects of delayed and current stimulus control in a successive discrimination is the time-related discrimination decrement reported by McLean and White (1981). This effect is a reduction in the sensitivity of response ratios to reinforcer ratios during the course of components. That is, at the beginning of components, response ratios are highly sensitive to changes in the ratio of reinforcers obtained by responses in the two components. Towards the end of components, the sensitivity of response ratios is low. The decrease in sensitivity to reinforcement with increasing time since the beginning of the component occurs reliably with hue stimuli (McLean & White, 1981; White, Pipe, McLean, & Redman, 1985b) or line-orientation stimuli (White, Pipe, & McLean, 1984) and with long and short component durations (Hunt, 1985; White, Pipe, McLean, & Redman, 1985a). A particularly interesting result reported by Nevin[1] is the decrement in sensitivity to reinforcement over 7-day long components. In general, the effect seems less likely to occur with highly discriminable stimuli (Williams, 1988). The effect may be related to local behavioral contrast, where absolute response rates in the richer component are ini-

[1] Nevin, J. A. (1988, May). *Overmatching and local contrast in a closed economy.* Paper presented to the Association for Behavior Analysis, Philadelphia.

tially high and then decrease following transition from the leaner component (Nevin & Shettleworth, 1966; Williams, 1983). The similarity between local contrast and the time-related discrimination decrement is incomplete, however. The two kinds of effects do not completely correlate (McLean & White, 1981), and the discrimination decrement is a change in the response differentials between the two components rather than a change in absolute response rate in one component.

The reason for suspecting that the time-related discrimination decrement may be influenced by both delayed and current stimuli is that, over the course of the component, the arranged and obtained reinforcer rates remain constant (Hunt, 1985; White et al., 1984). The only stimulus change is the transition at the beginning of the component. Indeed, the transition between discriminative stimuli may be the important event determining delayed control rather than the stimulus in the previous component per se.

The present experiment sought to determine the delayed influence of the component transition relative to the influence exerted by the stimulus signaling the current component. The exponent m of the power function given by Equation 1, relating ratios of responses ($P1$, $P2$) to the ratios of reinforcers obtained in the two components ($R1$, $R2$) was used as a higher order measure of discrimination (White, 1985; White, Pipe, & McLean, 1983; White et al., 1984). The power function has proved useful in describing performance in successive discriminations because the sensitivity of response rates to changes in reinforcer ratios (m) can be determined separately from any constant bias (q) that may exist between the components (Lander & Irwin, 1968; McLean & White, 1983; McSweeney, Farmer, Dougan, & Whipple, 1986; Williams, 1983). The power function is

$$P1/P2 = q(R1/R2)^m. \qquad (1)$$

We have suggested previously that the value of the exponent, m, provides a measure of discrimination independently of the effects of reinforcers (White et al., 1983, 1984). The discrimination measure is independent of reinforcer effects in that a given value of m is determined over a range of reinforcer ratios (analogous to the receiver operating characteristic of detection theory). When $m = 0$, re-

sponse ratios remain invariant with changes in reinforcer ratios, and there is a complete absence of stimulus control and no discrimination. The greater the extent of change in response ratios when reinforcer ratios are varied, the greater the discrimination and the larger the value of m. Our interpretation of m as a measure of discrimination was confirmed by the result of varying the disparity between line-orientation stimuli associated with different reinforcer rates in successive discriminations. As the line orientations become more different, the value of m increased systematically (White et al., 1983, 1984). Applied to the present case, a decrease in m with increasing time since the beginning of the component (McLean & White, 1981) reflects a decrease in discrimination or stimulus control over the course of the component (White et al., 1985a). The present experiment suggests that this discrimination decrement is the result of delayed control by the component transition, with maximal discrimination soon after component transition.

In the present experiment, several conditions were compared to a standard successive discrimination in which red and green hues signaling component variable-interval (VI) schedules alternated in direct succession. The conditions involved replacing both red and green by a white stimulus in different quarters of the component in order to remove the transition between component stimuli or to alter the potential sources of delayed and current stimulus control.

The general design of the experiment is illustrated in Table 1. Procedure A is the standard procedure with red and green in each component. This is the procedure for which we have reported previously the decrement in m over the course of the component. In Procedure B, a white stimulus replaced red and green in the last quarter of the components to remove the red–green transition. If the red–green transition in Procedure A has delayed control of the response differential in the first quarter (and perhaps second quarter) of the component, removing the transition will reduce the value of m in the first quarter of components in Procedure B. In Procedure C, it was asked whether the discriminative stimulus in the last quarter of the component, as opposed to the red–green transition, exerted delayed control over responding in the first

Table 1

Colors of stimuli in different quarters of components of multiple VI VI schedules for five procedures.

Proce-dure	Stimuli							
	Component 1 (VIx)				Component 2 (VIy)			
	1	2	3	4	1	2	3	4
A	Red	Red	Red	Red	Green	Green	Green	Green
B	Red	Red	Red	White	Green	Green	Green	White
C	White	White	White	Red	White	White	White	Green
D	Red	White	White	Red	Green	White	White	Green
E	Red	White	White	White	Green	White	White	White

quarter of the following component. Procedure D was included to assess the current control in the different quarters of the component. Because Procedure D reinstated the component transition, Procedure E was included as a further test of the effect of removing the transition on discrimination in the first quarter.

METHOD

Subjects

Five adult homing pigeons with previous experience in multiple schedules were maintained at 80% of their free-feeding weights. The birds were labeled R1 to R5. Grit and water were available in the living cages, and supplementary feeding with mixed grain ensured maintenance of the prescribed weights. Daily sessions were conducted for each bird unless its weight was outside ±5% of the prescribed weight.

Apparatus

An interface panel with a central 2.5-cm diameter response key, 25 cm from the grid floor, was mounted in a light-proof, sound-attenuating experimental chamber that was 32 cm wide, 34 cm deep, and 36 cm high. There was no houselight. The key could be illuminated by red, green, or white light except during reinforcement. Responses with a force exceeding 0.10 N were sufficient to operate the key, and each response produced a 0.04-s offset of the keylight. A central hopper opening allowed 2.5-s access to wheat from a Gerbrands hopper. Experimental events were controlled and recorded by solid-state apparatus in an adjacent room.

Procedure

All birds were introduced to the first experimental condition in the first session. In each session, the colors associated with two components that alternated in strict succession were presented on the center key. The duration of each component was 60 s. There was a total of 48 components in each session. The colors presented in the different 15-s quarters of components are given in Table 1 for all procedures. In Procedure A, red in one component alternated with green in the other. In Procedure B, the same white stimulus was presented in the last 15 s of each component, with the remainder of the components signaled by red and green. In Procedure C, red and green were presented in the last 15 s, with the remainder of both components associated with white. In Procedure D, the first and last 15 s of the components were signaled by red and green and the remainder of both components was associated with white. In Procedure E, red and green were presented in the first 15-s quarter, and the last three quarters of the components were associated with white.

Throughout each component, including periods of the white stimulus in each component, responses were reinforced according to a VI schedule. One VI schedule (VIx) was arranged in one component, and another, independent, VI schedule (VIy) was arranged in the other. Schedules were constructed from a constant-probability progression with 12 intervals. Reinforcers arranged in a component but not obtained by the end of the component were held over until the next presentation of the same component. (Such instances were rare because of high response rates throughout the session for all procedures. Further, we have

found that the discrimination decrement over the course of the component remains robust when reinforcers not obtained at the end of a component are canceled.)

The values of the VI schedules were varied over conditions. Table 2 gives the nominal values of the VI schedules used in the different conditions, the order in which the conditions were conducted, and the number of sessions required by each bird for performance in each condition to become stable. Conditions 1 to 7 (Procedure A) were conducted as part of the study reported by White et al. (1985b). These conditions were completed at different stages of the present experiment, as indicated by the order of conditions given in Table 2. Five reinforcer-ratio conditions were conducted for Procedures B, C, and D. Six conditions were conducted for Procedure E. Four of these were Conditions 6, 7, 8, and 9 reported briefly by Redman and White (1985). The data point for Condition 10 in that study was unreliable in relation to a line best fitting the other four points and was replaced by two replications (Conditions 27, 28) in the present study. Table 2 indicates when conditions for other studies were conducted and hence gives the complete history of each bird over 39 conditions. Table 2 also shows that the procedures were conducted sufficiently closely in time and with sufficient overlap of conditions to minimize the possibility of order effects. Procedures A and B were the most distant in order of conduct. The order in which the conditions were conducted for the different procedures was unsystematic. The stability criterion was that each condition should be conducted for at least 20 sessions and until the stage at which, in each of five consecutive sessions, responses in the richer component as a proportion of total responses did not exceed ±5% of the mean response proportion for the five sessions.

RESULTS

Analyses for individual birds were based on the total response frequencies in each of the 15-s quarters of the components and on total reinforcer frequencies obtained in each component. The response and reinforcer frequencies were summed over the last five sessions for each condition; these data represented stable performance and are given in the Appendix. With consistently high response rates over

components in the different conditions, reinforcers obtained in the different quarters of the component corresponded to the frequencies arranged by the constant probability schedules. However, total reinforcers over the whole component were used in the analyses because reinforcers within component quarters tended to vary unsystematically when summed over just the last 5 days. In other analyses, we have found that separating reinforcer frequencies by component quarter simply increases the standard errors of best fitting straight lines but does not alter their slopes (cf. Hunt, 1985; White et al., 1985b).

To assess the level of discrimination in the different component subintervals, logarithms (base 10) of ratios of responses in the subintervals were plotted as a function of the logarithms of ratios of reinforcers obtained in the two components. The logarithmic transformation of Equation 1 is a linear function with slope m and intercept of log q. That is,

$$\log(P1/P2) = m \log(R1/R2) + \log q. \quad (2)$$

The log ratio functions for Procedure A are presented in White et al. (1985b, Figure 2). These functions were characterized by a systematically decreasing slope (m) over the four 15-s quarters. The values of m averaged over birds were .53, .36, .26, and .26 for the four quarters, respectively. Figures 1, 2, 3, and 4 show the log ratio functions over successive quarters for Procedures B, C, D, and E, respectively. Straight lines were fitted to the data for each quarter by the method of least squares, according to Equation 2. The figures show the values for m, log q, and the standard error of the estimate (SE) for each best fitting line. In all cases, excellent fits of Equation 2 to the data are indicated by the very small values of the standard error.

In the following analyses, the slopes of the lines (m) are used as higher order measures of discrimination. Slopes for individual birds for the different procedures are summarized in Table 3. Values for log q approximated zero and showed no obvious systematic variation as a function of component subinterval.

The first question concerns the delayed control exerted by the red–green transition. If the transition is removed in Procedure B, is discrimination reduced? Figure 5 (first panel) shows the comparison between mean values of m for the 5 birds for Procedure A (filled points)

Table 2

Values (seconds) for multiple VI VI schedules, order in which conditions were conducted, and number of sessions required by each bird (R1 to R5) to satisfy the stability criterion.

Condition			Order	Sessions				
				R1	R2	R3	R4	R5
Procedure A (RRRR/GGGG)								
1	VI 240	VI 48	15	25	24	20	26	21
2	VI 120	VI 60	1	20	24	27	20	30
3	VI 80	VI 80	2	37	43	45	45	37
4	VI 60	VI 120	8	20	23	23	22	20
5	VI 48	VI 240	13	20	26	31	20	31
6	VI 240	VI 48	17	30	31	28	29	33
7	VI 48	VI 240	16	20	34	20	22	20
Procedure B (RRRW/GGGW)								
8	VI 240	VI 48	24	30	23	23	33	20
9	VI 120	VI 60	26	22	20	24	26	23
10	VI 80	VI 80	27	24	28	20	32	24
11	VI 60	VI 120	25	20	20	20	20	20
12	VI 48	VI 240	23	24	20	20	25	25
Procedure C (WWWR/WWWG)								
13	VI 240	VI 48	19	25	21	27	28	21
14	VI 120	VI 60	21	20	20	20	22	21
15	VI 80	VI 80	22	29	23	22	22	20
16	VI 60	VI 120	20	25	22	24	21	22
17	VI 48	VI 240	18	25	22	26	29	23
Procedure D (RWWR/GWWG)								
18	VI 240	VI 48	12	22	20	21	25	22
19	VI 120	VI 60	10	24	21	23	20	24
20	VI 80	VI 80	11	25	21	25	26	26
21	VI 60	VI 120	9	20	23	20	20	24
22	VI 48	VI 240	14[a]	23	20	22	23	23
Procedure E (RWWW/GWWW)								
23	VI 240	VI 48	4	47	44	47	46	47
24	VI 120	VI 60	7	25	25	27	28	27
25	VI 80	VI 80	3	30	30	28	30	30
26	VI 60	VI 120	5	20	26	27	22	25
27	VI 48	VI 240	6	20	23	24	23	26
28	VI 48	VI 240	28[b]	22	23	25	22	21

[a] Between conditions 22 and 1 (14th and 15th in order) there was condition 10 of Redman and White (1985), followed by the seven 15-s component conditions reported in White et al. (1985b).
[b] Condition 28 was preceded by two conditions with 10-s components (White et al., 1985a).

and Procedure B (unfilled points). Differences between mean m values referred to below were consistent with corresponding differences for individual birds summarized in Table 3. (Reliability of the differences was also confirmed by post hoc comparisons following analysis of variance, but these analyses are not presented here.) In the first quarter (Figure 5, first panel), m was lower for Procedure B than for Procedure A. In Procedure B, the first quarter of the component was preceded by the white stimulus (i.e., the red-green transition was removed). The effect of the transition in Pro-

cedure A was therefore to increase m in the first quarter and to a lesser extent in the second quarter. In the last quarter for Procedure B, m was less than .1 because red or green was no longer present to maintain a response differential. The small response differentials that did occur ($m < .1$) in the white stimulus are the possible result of discriminating reinforcer-frequency differences (cf. White et al., 1984) or of delayed control by the red or green stimuli presented earlier in the component.

Figure 5 (second panel) shows the mean values of m for Procedure A compared to Pro-

Fig. 1. Logarithms (base 10) of response ratios as a function of logarithms of reinforcer ratios in successive quarters of components in Procedure B (RRRW/GGGW) for individual birds. Values of sensitivity (*m*), bias (log *q*), and the standard error of the estimate are given for each best fitting linear function to the upper left of each function.

Fig. 2. Logarithms (base 10) of response ratios as a function of logarithms of reinforcer ratios in successive quarters of components in Procedure C (WWWR/WWWG) for individual birds. Values of sensitivity (*m*), bias (log *q*), and the standard error of the estimate are given for each best fitting linear function.

Fig. 3. Logarithms (base 10) of response ratios as a function of logarithms of reinforcer ratios in successive quarters of components in Procedure D (RWWR/GWWG) for individual birds. Values of sensitivity (*m*), bias (log *q*), and the standard error of the estimate are given for each best fitting linear function.
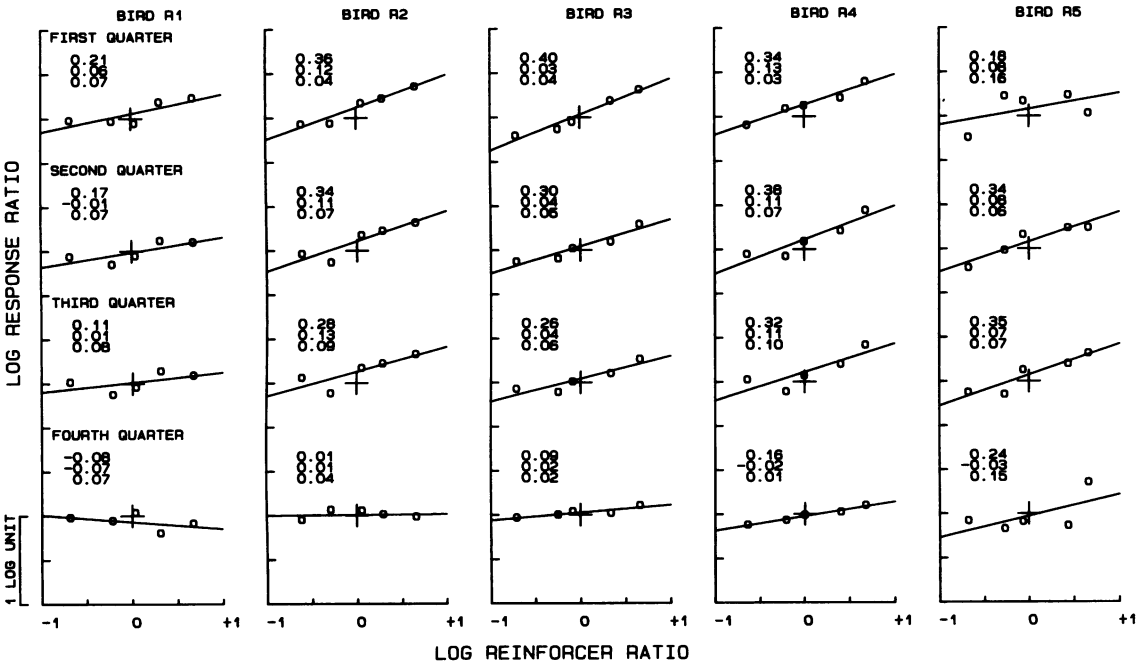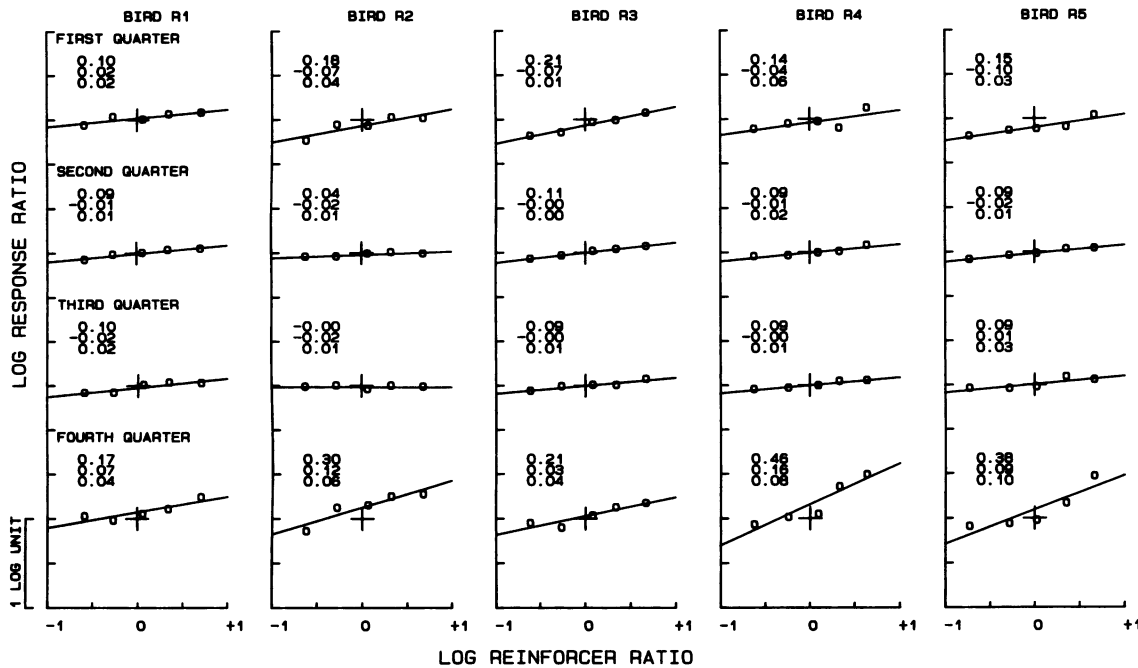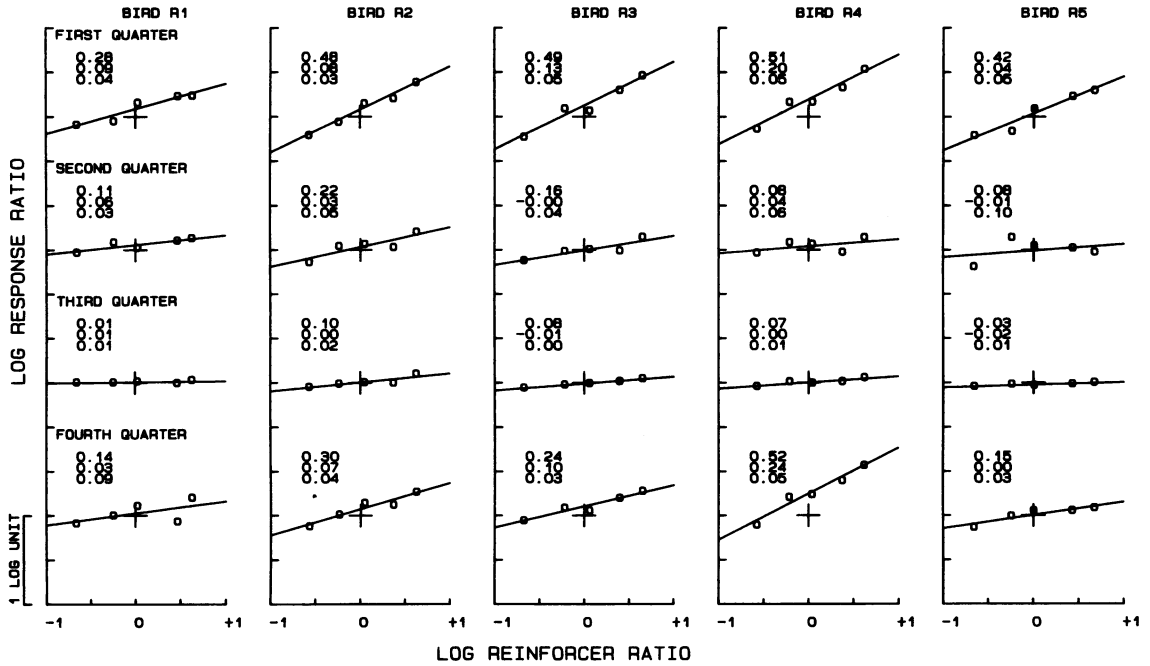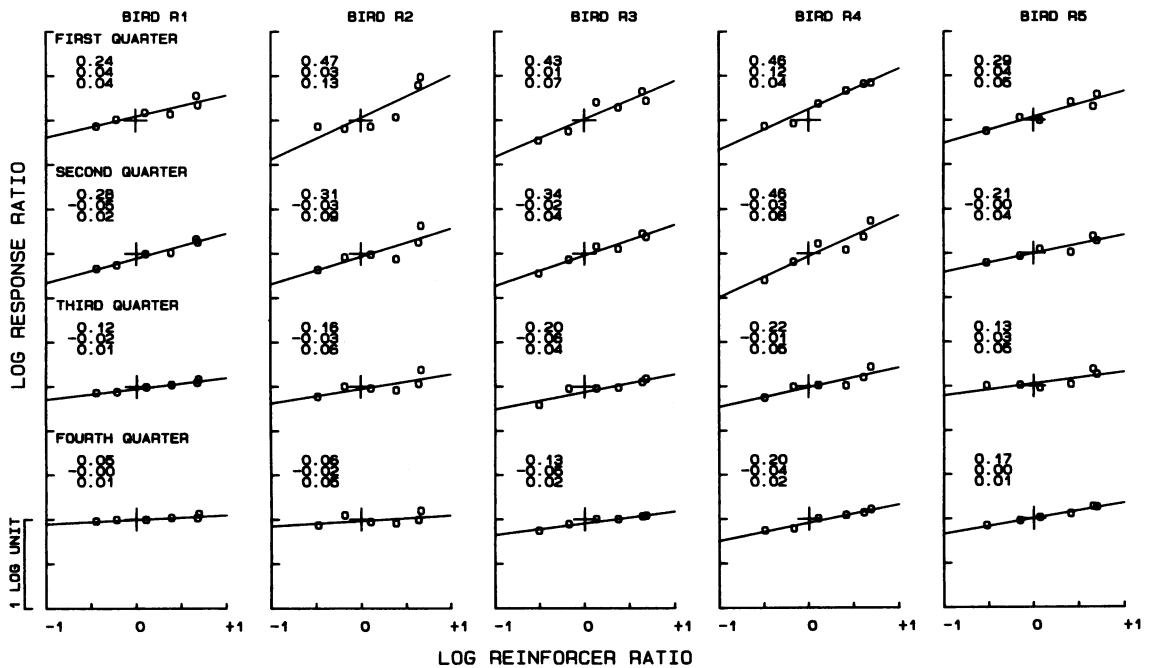

Fig. 4. Logarithms (base 10) of response ratios as a function of logarithms of reinforcer ratios in successive quarters of components in Procedure E (RRRW/GWWW) for individual birds. Values of sensitivity (*m*), bias (log *q*), and the standard error of the estimate are given for each best fitting linear function.
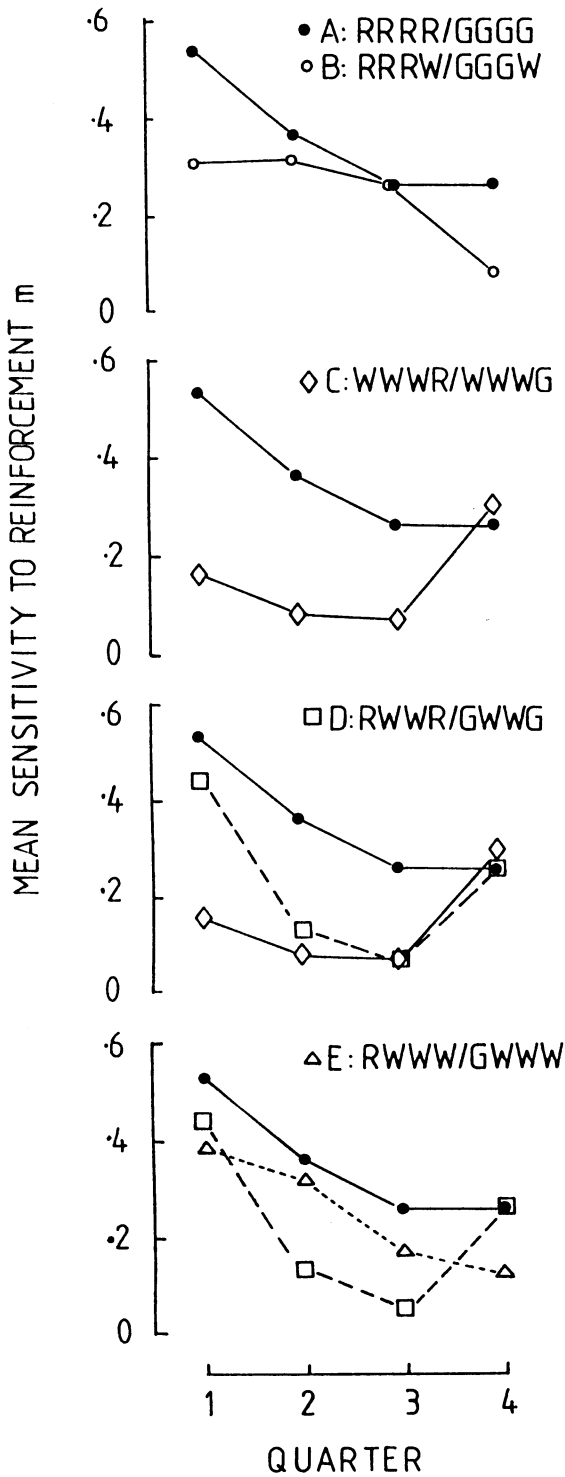
Fig. 5. Values of sensitivity, *m*, averaged over birds for successive quarters of components of Procedure A (filled points) and Procedures B, C, D, and E (unfilled points). Colors presented in the components are indicated by R (red), G (green), and W (white).

Table 3

Values of discrimination, *m*, from Equation 1, over 15-s subintervals in the different procedures.

	Subinterval			
Bird	1	2	3	4
Procedure A				
R1	.40	.20	.14	.15
R2	.56	.37	.23	.20
R3	.62	.35	.25	.23
R4	.51	.54	.50	.49
R5	.55	.33	.20	.25
Procedure B				
R1	.21	.17	.11	−.08
R2	.36	.34	.28	0
R3	.40	.30	.26	.09
R4	.34	.38	.32	.16
R5	.18	.34	.35	.24
Procedure C				
R1	.10	.09	.10	.17
R2	.18	.04	0	.30
R3	.21	.11	.09	.21
R4	.14	.09	.09	.46
R5	.15	.09	.09	.38
Procedure D				
R1	.28	.11	.01	.14
R2	.48	.22	.10	.30
R3	.49	.16	.08	.24
R4	.51	.08	.07	.52
R5	.42	.08	.03	.15
Procedure E				
R1	.24	.28	.12	.05
R2	.47	.31	.16	.06
R3	.43	.34	.20	.13
R4	.46	.46	.22	.20
R5	.29	.21	.13	.17

cedure C, in which red and green were presented only during the last quarter of the component. The question addressed by this comparison was whether the discriminative stimulus at the end of the preceding component exerted delayed control over responding at the beginning of the component. There was a small amount of delayed control by the stimulus in the preceding component in that *m* for the first quarter was marginally higher than for the second and third quarters. In the first, second, and third quarters, *m* was lower for Procedure C than for Procedure A. In the last quarter, *m* was the same for both procedures. That is, *m* in the last quarter was unaffected by whether the last quarter was preceded by red–green or white. Control of responding in the last quarter was therefore determined solely by the current stimulus.

Procedure D involved reinstatement of the transition between red and green discriminative stimuli to investigate further the sources of control in the second and third quarters. Figure 5 (third panel) shows the comparison among Procedures A, C, and D. The main interest is in m for the second and third quarters. The higher value of m for the second quarter than for the third quarter of Procedure D suggests that responding in the second quarter was under delayed control by the color in the first quarter or by the component transition. In the third quarter, m was the same as for the third quarter of Procedure C (in which there was no delayed control). Responding in the third quarter as well as the last quarter was therefore influenced only by the current stimuli (consistent with the conclusion from comparing Procedures A and C). The parallel decrease in m over the first three quarters of the component for Procedures A and D further suggests that response differentials in the first half of the component were influenced by the delayed effects of component transition as well as by the current discriminative stimulus, whereas response differentials in the second half of the component were maintained solely by the current stimulus.

Because Procedure D involved reinstating the red–green component transition, a further test of delayed control by component transition was afforded by a comparison to Procedure E, in which red and green were presented only in the first quarter. Figure 5 (fourth panel) shows that the value of m in the first quarter in Procedure D was higher than in Procedure E, as expected if component transition has delayed control over responding in the first quarter. This difference occurred for each bird (Table 3), although this difference is relatively small. The lower value of m in the first quarter in Procedure E than in Procedure A is also consistent with delayed control by component transition.

DISCUSSION

The purpose of the present experiment was to isolate the possible sources of delayed and current stimulus control in successive discriminations. The progressive decrease in m over the course of the component found in previous studies (Hunt, 1985; McLean & White, 1981; White et al., 1984; Williams, 1988) is a combination of the changing contribution of delayed and current stimulus control. Throughout the component, the current discriminative stimulus exerts control over responding. During about the second half of components, response differentials are maintained solely by the current stimuli. During the first half of the component, responding is also influenced by the transition between discriminative stimuli. Delayed control by the transition is strongest soon after the transition. As the component progresses, delayed control by the component transition decreases. The discriminative stimulus in the preceding component does not by itself influence responding in the following component; the transition between the discriminative stimuli seems to be the important event.

The present analysis assumes that the introduction of white at the end of components eliminates component transition. Of course, a transition actually remains, namely that between the white stimulus signaling an "average" reinforcement rate and the red or green color at the beginning of the next component. The possibility that white may not have equal (or no) control in each component is indicated by the anomaly that m for the first quarter was slightly lower in Procedure D than in Procedure A, although both procedures incorporated a red–green transition. The low value of m in Procedure D is the likely result of induction from low response differentials during white, although it is not clear why these response differentials should be low when higher differentials were maintained in the same quarters in Procedure E. Nevertheless, it is difficult to conceive of an arrangement that completely removed transitions. An alternative strategy is to search for converging sources of evidence from different transition manipulations, such as interpolating a blackout between components.

Although the earlier relational accounts of discrimination did not specify the nature of the "stimulus comparison" that was thought to be important to discrimination (Lashley & Wade, 1946; Lawrence, 1963; Mackintosh, 1974; Riley, Ring, & Thomas, 1960), the present conclusion that the transition between discriminative stimuli exerts delayed control over discriminative responding is consistent with a relational view, in that the transition defines a relation. The transition requires temporal proximity of the components. It may be assumed, therefore, that operations that inter-

rupt temporal proximity, such as interpolation of a blackout between components, will attenuate delayed stimulus control by the transition (Redman & White, 1985; White & Redman, 1983). This assumption has yet to be tested directly, but has some support from the elimination of local contrast (high response differentials at the beginning of components) with the introduction of longer blackouts between VI and extinction components (Mackintosh, Little, & Lord, 1972).

The changes in m over component quarters have been interpreted here in terms of discrimination changes, rather than as changes in behavioral contrast. Indeed, the present conditions did not include a contrast manipulation in which reinforcement rate in one component was held constant and, therefore, do not allow any conclusions concerning contrast. The present data are amenable, however, to interpretation in terms of the theory of differential responding in multiple schedules proposed by McLean and White (1983). White (1978) showed that responding within each component of a multiple schedule reflected differential time allocation between responding and other behavior. In order to predict multiple-schedule sensitivity (m), McLean and White quantified ratios of operant responding to other behavior within each multiple-schedule component in terms of the generalized matching law. That is, response rates within each component are determined by the relation between food reinforcers obtained by responding and concurrently available extraneous reinforcers obtained by other behavior (Herrnstein, 1970). According to McLean and White's quantitative prediction for response ratios in the two components, m is a function of the sensitivity of behavior allocation within components to concurrently available food and extraneous reinforcers. McLean (1990) demonstrated that sensitivity to concurrent reinforcement within each component of a two-component multiple-concurrent schedule was highest soon after stimulus transition. McLean's result cannot be explained in terms of a change in extraneous reinforcement rate within components, because reinforcement rates remained constant.

Applied to the time-related discrimination decrement in successive discriminations, time since component transition exerts delayed control over the concurrent choice within components. Construed in these terms, suc-cessive discrimination is a matter of "knowing what to do when." In that delayed control is stronger at the beginning of components, the concurrent choice and hence the multiple-schedule response ratio will be most strongly differentiated at the beginning of the component. Relational determinants of successive discrimination may thus be found in the temporal control of concurrent choice.

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APPENDIX

Response frequencies in successive 15-s quarters and reinforcer frequencies in each component summed over the last 5 days of each condition.

Condition	Component 1 responses				Component 2 responses				Reinforcers	
									Comp 1	Comp 2
	1	2	3	4	1	2	3	4		
Procedure A (RRRR/GGGG)										
1–7	(See Table 2, White et al., 1985b)									
Procedure B (RRRW/GGGW)										
Bird R1										
8	1,613	1,613	1,737	1,059	1,716	1,887	1,689	1,124	23	119
9	1,540	1,227	1,272	1,036	1,679	1,756	1,715	1,191	55	97
10	2,028	1,912	1,848	1,505	2,335	2,190	2,059	1,406	72	71
11	2,591	2,688	2,710	896	1,707	2,071	1,971	1,431	99	52
12	1,890	1,669	1,682	822	1,128	1,345	1,381	1,016	115	26
Bird R2										
8	1,321	1,492	1,998	1,577	1,579	1,648	1,761	1,803	27	118
9	1,490	1,284	1,340	1,616	1,751	1,767	1,774	1,417	53	110
10	2,080	2,221	2,213	1,444	1,436	1,502	1,514	1,293	73	69
11	2,539	2,543	2,592	1,639	1,555	1,536	1,578	1,621	98	54
12	2,304	2,438	2,617	1,203	1,035	1,190	1,250	1,269	114	27
Bird R3										
8	1,585	1,697	1,916	1,654	2,592	2,325	2,300	1,810	21	117
9	1,745	1,426	1,333	1,461	2,412	1,802	1,742	1,475	55	104
10	1,876	1,697	1,709	1,615	2,155	1,647	1,691	1,502	72	94
11	2,226	1,599	1,522	1,583	1,469	1,303	1,216	1,541	106	52
12	2,881	3,005	2,999	2,016	1,429	1,556	1,650	1,603	115	27
Bird R4										
8	805	997	1,160	668	1,015	1,146	1,109	896	26	122
9	1,040	811	710	534	857	989	931	634	56	97
10	1,338	1,324	1,280	894	1,014	1,097	1,101	929	77	83
11	1,489	1,500	1,383	835	931	938	885	803	113	48
12	1,357	1,495	1,471	994	556	548	571	802	115	26
Bird R5										
8	1,095	1,329	1,654	1,139	1,931	2,198	2,233	1,390	24	122
9	2,116	1,531	1,145	918	1,275	1,619	1,635	1,385	55	110
10	1,675	1,763	1,745	959	1,149	1,243	1,317	1,203	74	92
11	2,184	2,087	1,893	776	1,290	1,234	1,219	1,082	130	51
12	1,296	2,211	2,381	1,555	1,225	1,298	1,166	698	115	27

APPENDIX (*Continued*)

Condition	Component 1 responses				Component 2 responses				Reinforcers	
	1	2	3	4	1	2	3	4	Comp 1	Comp 2
Procedure C (WWWR/WWWG)										
Bird R1										
13	1,030	1,056	1,060	1,269	1,198	1,272	1,289	1,208	32	132
14	1,280	1,234	1,167	1,211	1,192	1,295	1,412	1,279	50	99
15	1,185	1,247	1,223	1,559	1,184	1,253	1,206	1,400	81	75
16	1,286	1,217	1,284	1,453	1,119	1,130	1,192	1,151	102	49
17	1,272	1,348	1,325	1,923	1,062	1,217	1,250	1,123	119	25
Bird R2										
13	1,416	1,875	1,928	1,906	2,465	2,091	2,002	2,668	28	126
14	1,565	1,523	1,604	2,695	1,807	1,692	1,613	2,061	51	104
15	1,423	1,498	1,431	2,662	1,691	1,539	1,584	1,911	76	70
16	1,639	1,513	1,523	2,961	1,554	1,502	1,537	1,690	103	52
17	1,761	1,686	1,686	3,133	1,708	1,737	1,748	1,685	117	26
Bird R3										
13	1,184	1,361	1,400	2,067	1,839	1,618	1,628	2,357	29	128
14	1,496	1,581	1,543	2,307	2,124	1,724	1,589	2,959	52	103
15	1,408	1,290	1,287	2,409	1,536	1,248	1,281	2,261	72	64
16	1,480	1,532	1,367	2,748	1,533	1,410	1,368	2,089	104	51
17	1,893	1,837	1,775	2,516	1,621	1,571	1,518	1,709	118	27
Bird R4										
13	898	968	955	1,174	1,179	1,087	1,075	1,396	29	131
14	812	909	899	1,294	931	1,000	976	1,273	53	99
15	781	853	809	1,279	845	872	826	1,170	75	65
16	657	822	857	1,586	841	815	783	709	99	50
17	1,244	1,154	1,097	1,975	949	974	982	649	120	30
Bird R5										
13	1,155	1,522	1,673	1,812	1,844	1,878	1,850	2,268	26	150
14	1,101	1,304	1,363	2,249	1,520	1,448	1,520	2,627	49	101
15	1,104	1,356	1,378	2,337	1,462	1,433	1,472	2,512	76	77
16	998	1,262	1,538	2,691	1,257	1,190	1,264	1,866	101	48
17	1,452	1,634	1,627	2,558	1,346	1,508	1,445	883	117	27
Procedure D (RWWR/GWWG)										
Bird R1										
18	1,180	1,147	1,183	1,135	1,468	1,239	1,181	1,402	24	117
19	1,518	1,429	1,136	1,589	1,728	1,184	1,133	1,600	55	103
20	1,807	1,354	1,283	1,683	1,276	1,292	1,248	1,319	75	76
21	1,332	951	703	1,023	794	754	715	1,208	115	42
22	1,930	1,753	1,515	2,068	1,137	1,308	1,419	1,314	115	29
Bird R2										
18	1,429	1,217	1,406	1,730	2,340	1,696	1,584	2,323	30	120
19	1,912	1,776	1,490	1,892	2,220	1,629	1,546	1,866	55	102
20	2,609	1,723	1,580	2,547	1,876	1,490	1,577	1,855	74	71
21	2,361	1,666	1,539	2,555	1,490	1,570	1,555	1,954	121	55
22	3,078	2,062	1,771	3,101	1,281	1,303	1,413	1,691	115	29
Bird R3										
18	1,505	1,695	1,646	1,916	2,581	2,259	1,904	2,215	24	121
19	2,712	2,057	1,576	2,446	2,218	2,144	1,672	2,024	55	97
20	2,333	1,820	1,775	2,245	2,023	1,828	1,819	2,007	74	69
21	2,788	1,573	1,691	2,799	1,421	1,625	1,641	1,799	123	53
22	2,877	1,930	1,650	2,828	1,002	1,388	1,492	1,507	113	27

APPENDIX (*Continued*)

Condition	Component 1 responses				Component 2 responses				Reinforcers	
									Comp 1	Comp 2
	1	2	3	4	1	2	3	4		
Bird R4										
18	942	892	958	945	1,305	975	1,064	1,227	29	117
19	1,484	1,211	826	1,457	1,027	1,010	812	913	55	96
20	1,282	918	838	1,369	882	798	852	802	73	71
21	1,688	750	862	-1,755	805	803	844	713	114	51
22	2,209	1,270	1,103	2,308	652	925	974	627	114	29
Bird R5										
18	1,482	1,149	1,396	1,785	2,429	1,795	1,556	2,464	24	117
19	2,065	1,631	1,444	1,508	1,402	1,190	1,518	1,549	55	103
20	2,469	1,888	1,733	2,309	2,035	1,715	1,872	2,068	74	78
21	2,277	1,550	1,412	2,162	1,357	1,486	1,468	1,933	121	48
22	2,118	1,624	1,688	2,555	1,084	1,733	1,683	2,126	115	26
Procedure E (RWWW/GWWW)										
Bird R1										
23	1,078	887	1,092	1,144	1,278	1,331	1,299	1,216	40	119
24	1,156	909	958	902	1,151	1,241	1,116	923	60	106
25	1,189	997	1,012	1,019	986	1,018	1,039	1,042	83	70
26	1,277	1,242	1,257	1,245	1,105	1,232	1,217	1,208	116	51
27	1,383	1,296	1,187	1,131	948	977	997	996	129	28
28	1,525	1,762	1,634	1,614	817	1,229	1,493	1,572	115	26
Bird R2										
23	1,272	1,025	1,171	1,308	1,519	1,585	1,548	1,550	37	119
24	1,337	1,371	1,445	1,645	1,685	1,533	1,462	1,499	65	105
25	1,521	1,322	1,400	1,388	1,822	1,379	1,489	1,507	88	73
26	1,445	1,339	1,431	1,379	1,355	1,562	1,594	1,547	115	50
27	2,467	1,716	1,573	1,496	818	846	1,032	1,219	131	30
28	2,932	1,773	1,552	1,464	1,202	1,341	1,470	1,506	115	28
Bird R3										
23	1,752	1,242	1,468	1,752	3,021	2,125	2,411	2,408	35	121
24	1,855	1,595	1,681	1,644	2,519	1,901	1,798	1,894	63	101
25	2,394	1,984	1,923	1,975	1,530	1,678	2,044	1,996	90	71
26	2,092	1,939	1,987	2,098	1,528	1,745	2,076	2,126	115	52
27	2,102	1,886	1,885	1,856	1,292	1,244	1,572	1,721	136	30
28	3,602	2,346	1,916	1,806	1,737	1,422	1,734	1,706	115	28
Bird R4										
23	1,533	680	710	680	1,827	1,385	970	935	36	120
24	1,302	747	737	654	1,444	938	757	854	64	101
25	1,623	970	826	812	1,079	765	818	817	91	76
26	2,522	736	734	794	1,192	682	735	731	117	48
27	2,464	1,465	985	754	954	639	606	598	138	30
28	1,642	1,063	1,004	907	652	703	812	784	115	30
Bird R5										
23	1,713	992	1,390	1,346	2,315	1,297	1,403	1,640	33	118
24	2,086	1,572	1,611	1,486	1,992	1,726	1,603	1,595	69	105
25	2,617	2,252	2,435	2,515	2,677	2,069	2,610	2,497	80	73
26	2,164	1,321	1,567	1,705	1,379	1,318	1,530	1,535	116	48
27	2,243	1,506	1,546	1,554	1,170	1,109	1,162	1,178	136	29
28	1,627	1,153	1,169	1,096	1,165	755	769	817	115	27